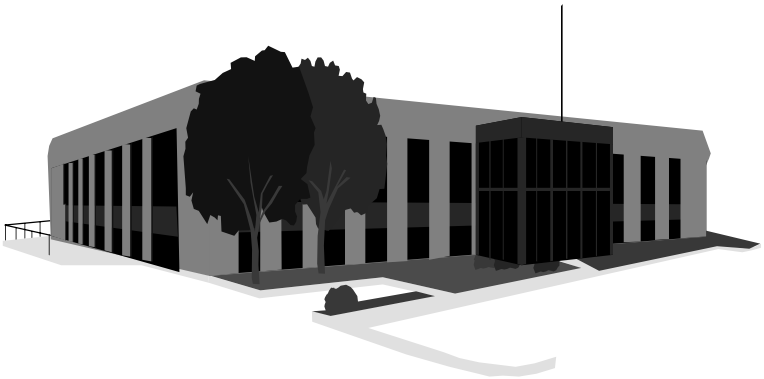
INDOOR AIR QUALITY REASSESSMENT

Clarksburg Elementary School
Clarksburg School District
777 West Crossroad
Clarksburg, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
February, 2001

Background/Introduction

At the request of the Clarksburg School Department, an indoor air quality assessment was conducted at the Clarksburg Elementary School in Clarksburg, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA).

The school was originally visited by Michael Feeney, Chief of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, on October 7, 1999. A report was issued (MDPH, 1999) which described the conditions of the building at that time. The report showed that there were problems identified and gave recommendations on how to correct those problems. This assessment followed the completion of most of those recommendations. Since the building had under gone substantial repair, the conditions described in the BEHA 1999 report would be expected to be different. On October 12, 2000, and October 17, 2000, Mr. Feeney returned to the school to conduct a re-evaluation of the building.

The Clarksburg School Department followed a substantial number of recommendations made in the previous reports. Of primary importance is the improvement of conditions in the new wing. Clarksburg School Department actions have resulted in the elimination of mold odors in classrooms throughout the new wing and an overall improvement in the indoor air quality in the building.

Actions on Recommendations

BEHA had previously made a number recommendations to improve indoor air quality at the school (MDPH, 1999). School officials reported that they have acted on all of these recommendations that are in control of school department personnel. The following is a status report of action(s) on BEHA's **short-term** recommendations based on reports from school officials, documents, photographs and BEHA staff observations.

1. **Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Operate univents while classrooms are occupied. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.**
   A ventilation engineer (Alex Alexandrovich) was consulted to resolve air supply/exhaust ventilation issues building-wide. This engineer was reportedly consulted to examine and adjust univents in classrooms throughout the building. Ten univents were replaced in the old building. The univent in classroom 8 is scheduled for replacement.
2. **Repair exhaust vent fan motors. Operate exhaust vents during school hours.**
   Exhaust vent fan motors have been repaired, however a number of them were not operating at the time of this re-evaluation.
3. **Remove all blockages from univents and exhaust vents to facilitate airflow. Consider removing coat closet doors to prevent blockage or re-locating passive door vents to the top of coat closet doors to improve exhaust ventilation.**
   Efforts have been made to eliminate blockages from ventilation vents. However, some classrooms still have blocked univents. The passive door vents in the closet doors were moved to the top of the doors as recommended (see Picture 1).

4. **Once fresh air supply is increased, the ventilation system should be balanced.**

   The repair of univents and exhaust vents is an ongoing process. Once all of the ventilation systems are repaired and fully operation, then ventilation system balancing should be done.

5. **Permanently seal the vent in room 5.**

   The vent grille was removed and the wall hole was sealed (see Picture 2).

6. **Temporarily seal the vent hole pictured in room 1. If this is done, the corresponding hole in the exterior should also be temporarily rendered airtight to prevent moisture penetration. Examine the newer wing floor for spaces and seal to prevent air penetration.**

   Please refer to the ventilation section of this report.

7. **Examine the fiberglass insulation beneath the newer wing floor for mold colonization. If mold growth is present, replace the fiberglass. Examine floorboards and joists for mold growth and disinfect with an appropriate antimicrobial. Remove debris from the floor of the newer wing crawlspace.**

   Debris was removed from the crawlspace floor (see Picture 3). The floor has been sealed with a plastic vapor barrier to prevent water penetration`.

8. **Move plants away from univents in classrooms. Examine drip pans for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in certain areas.**

   Plants have been relocated away from univents in all but one classroom.

9. **Store chemicals and cleaning products properly.**

   Cleaning products were removed from classrooms.

The following is a status report of action(s) on BEHA's **long-term** recommendations based on reports from school officials, documents, photographs and BEHA staff observations.

1. **Consider installing a gutter/downspout system on the edge of the newer wing's peaked roof to direct water away from the base of the wing and its crawlspace vents. The installation of a drainage system may also be necessary to direct water away from the base of the foundation.**

   A gutter downspout system was installed along the roof edge (See Pictures 4 and 5). Downspouts are connected to a storm drain that directs water away from the base of the building. The interiors of foundation walls were dry and appeared to be free of moisture (see Picture 6).

2. **Consult a building engineer concerning the most appropriate method to provide active mechanical exhaust ventilation to place the crawlspace under negative pressure. Placing the crawlspace under negative pressure will reverse air penetration into occupied spaces. Please note that a crawlspace exhaust vent should not expel crawlspace air near univent fresh air intakes.**

   A mechanical exhaust vent system was installed in the crawlspace (see Picture 7). This exhaust vent draws crawlspace air and expels it directly outdoors (see Picture 8).

3. **Consider consulting a building engineer to determine the most appropriate method to insulate and install a vapor barrier for the wing floor.**

   A vapor barrier was installed on the floor of the crawlspace (see Picture 3)

4. **In areas without exhaust ventilation, consider consulting a ventilation engineer to determine whether mechanical exhaust ventilation can be retrofitted/installed in these areas. Consider the use of the crawlspace or attic area of the newer wing as potential spaces for mechanical exhaust ventilation to be installed. The**

installation of mechanical exhaust ventilation may be necessary to provide airflow in the newer wing of this building.

Please refer to the ventilation section of this report.

5. **Consult a ventilation engineer to determine if the wall holes in room 1 can be used to retrofit mechanical exhaust ventilation. If the ventilation engineer chooses not to use these holes to retrofit mechanical exhaust ventilation, permanently seal the interior wall hole in the similar manner as described in short term recommendation #3. The exterior wall hole should be sealed with brick and mortar.**

   Please refer to the ventilation section of this report.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551.

Results

This school has a population of approximately 215 kindergarten through 8th grade students and a staff of approximately 40. Tests were taken under normal operating conditions. Test results appear in Tables 1-2.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were still elevated above 800 parts per million of air (ppm) in 15 of 18 areas surveyed within the school. This indicates that there are still ventilation issues in the building. It should be noted however, that in many classrooms carbon dioxide levels were lower than when previously tested by BEHA, despite higher occupancy (see Tables 3 and 4). It would be expected that carbon

dioxide levels would rise as occupancy increases. As an example, classroom 18, which had levels of carbon dioxide in excess of 2,000 ppm during the first visit's air monitoring with twelve occupants in the room, had a carbon dioxide level of 1,140 ppm with seventeen occupants during the re-assessment, indicating that the fresh air ventilation has improved in the school.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and draw return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and heating coil and is then expelled from the univent by motorized fans through fresh air diffusers. As previously mentioned, ten new univents have been installed. Univents were on in all but two classrooms. The univent in classroom 8 was not functioning at the time of the assessment. School maintenance personnel reported that a part for this univent is missing and it is scheduled to be replaced. However, obstructions to airflow, such as boxes and desks, were still observed in classrooms. In order for univents to provide fresh air as designed, the fresh air intakes, return intakes and air diffusers must be unblocked and remain free of obstructions.

Mechanical exhaust ventilation in the older wings of the building is provided by a mechanical, ducted ventilation system. Mechanical exhaust vents in rooms 14, 15, 16, 17, 18 and 19 were not drawing air, which can indicate the roof top motor servicing these areas was not functioning. Exhaust vent motors were in the process of being repaired/replaced as recommended in our previous report. **On February 6, 2001, Mr. John Barry, Clarksburg Superintendent of Schools, reported that repairs of a loose wire reactivated the non-functional exhaust vents noted in this report.**

The newer wings do not have mechanical exhaust vents. Closer examination of classrooms 2, 3 and 4 were equipped with "pressure dampers" (see Appendix for

reproductions of the original heating and ventilation blueprints for this wing). The position for each pressure damper is denoted by the symbol (z). This type of ventilation system relies on positive pressure created by the univents to force air out of the pressure dampers. As the univent operates, air pressure increases as additional fresh air is introduced into the classroom (called positive pressure). As positive pressure increases, air is forced out of the room through the wall vent and door spaces. The passive vent is designed to allow for slow release of air from classrooms by increasing positive pressure created by the univent. The design of these exhaust vents requires that classroom hallway doors remain closed to the extent practical in order to maintain positive pressure. With hallway doors open, classroom air would be forced into hallways.

According to the blueprints, all of the rooms in the 1990 addition were supposed to have pressure dampers installed, but none of these areas have functional pressure dampers. Rooms adjacent to the old building do not have openings in the exterior wall to release air outdoors. Classrooms adjacent to the library and room 1 may have had pressure dampers, but these openings were enclosed indoors by the 1990 addition. Therefore these rooms have no means to exhaust air from the classroom. Room 1 has an exterior wall vent, but as denoted in the previous report, this vent was sealed with fiberglass insulation. It appears that either these pressure dampers were never installed, they were rendered inoperable by renovations, or sealed. As a result, no means of exhaust, mechanical or passive, exists in the new wing.

The installation of an exhaust ventilation system in the basement can provide some exhaust ventilation by exfiltration of air from occupied spaces to the crawlspace through spaces in floors and walls. By operating the univents in the new wing without means of exhaust, each room will be placed under positive air pressure, which will force air through wall and floor spaces. The operation of the newly installed exhaust ventilation system places the crawl space under negative pressure, which will draw air

from the occupied space. The combination of univents creating positive pressure with the crawlspace exhaust vent system creating negative pressure may provide some exhaust ventilation for the new wing. In order to have this design function, univents must operate at all times and classroom doors must remain closed as much as practicable.

In order to have proper ventilation with a univent and exhaust system, these systems must be operable and balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air. Since the ventilation system is undergoing repair, balancing of supply and exhaust vents should be done once repairs are complete.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997, BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm) (OSHA, 1997). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population

in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 70^0 F to 73^0 F, which were within the BEHA recommended comfort range in all areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70^0 F to 78^0 F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. On February 6, 2001, Mr. Barry reported that the thermostat controlling temperature in the original wing was replaced.

Relative humidity measurements ranged from 34 percent to 46 percent, which was within or close to the BEHA recommended comfort range. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Mold and Mildew

The newer wing of the building (with the exception of room 1) is built on a cement foundation. The floor of the crawlspace beneath these classrooms is dirt. Two passive air vents are located on the north and south foundation walls at ground level (see Figure 2). This wing is covered with a peaked, shingled roof. A gutter system was installed to carry rainwater away from the base of the building. A plastic liner was installed to cover the floor and walls of the crawlspace. During the last visit (Oct. 1999), moisture was seen at the sill/foundation junction as well as on the interior of the

foundation walls. The crawlspace area at the time of the re-evaluation appeared to be dry.

Classroom 15 had a plant located on top of the univent. As mentioned in our previous report, plants should be located away from univents and exhaust ventilation to prevent the aerosolization of mold, dirt and pollen. Plant soil and drip pans can also provide a source of mold growth. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames.

Several classrooms have sinks that have a seam between the countertop and wall. Water penetration through this seam can result if not watertight. Water can penetrate the countertop seam and collect behind this board. Water penetration and chronic moisture exposure to plywood, corkboard and other porous materials can cause water damage and serve as a growth medium for mold. As a preventative measure by maintenance staff, these seams were sealed throughout the school with a caulking material (see Picture 9).

Other Concerns

An odor was noted emanating from the stairs leading to the boiler room. These odors were attributed the boiler room door being ajar (see Picture 10). A counterweight that would close this door flush with the doorframe was missing. Boiler room odors can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

The efforts of the Clarksburg School Department to eliminate mold odors initially detected in the new wing were successful. The MDPH is satisfied that the installation of the gutter/downspout system, removal of materials from the crawlspace, installation of a vapor barrier and installation of a mechanical exhaust vent system in the crawlspace have

removed the source of odors in the new wing. The repair/new installation of univents and restructuring of exhaust vents in closet doors throughout the building has resulted in an improvement in ventilation in the building. Ongoing repair and operation of exhaust vents, continued efforts to remove blockages near univents and subsequent balancing of these systems will further improve indoor air quality in the building.

In view of the findings at the time of this visit, the following recommendations are made:

1. Continue with repair of the univents and exhaust vent systems. Once repairs are complete, these systems should be balanced by an HVAC engineering firm and should operate during school hours.
2. Since the new wing does not have a mechanical exhaust ventilation system or functional pressure dampers, extreme care should be taken in using materials that contain chemicals: dry erase markers, permanent markers, rubber cement, air fresheners, cleaners (containing bleach or ammonia-related materials), and other materials that produce volatile organic compounds (VOCs) or dusts. In addition, scrupulous cleaning practices in the new wing should be adopted to minimize common indoor air particulates. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with regular wet wiping of all surfaces is recommended.
3. Replace missing counterweight to boiler room door.
4. Move plants away from univents in classrooms. Examine drip pans for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in certain areas.
5. Remove any remaining blockages from univents.

References

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

MDPH. 1999. Clarksburg Elementary School, Clarksburg, MA, Indoor Air Quality Assessment. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA. November, 1999.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

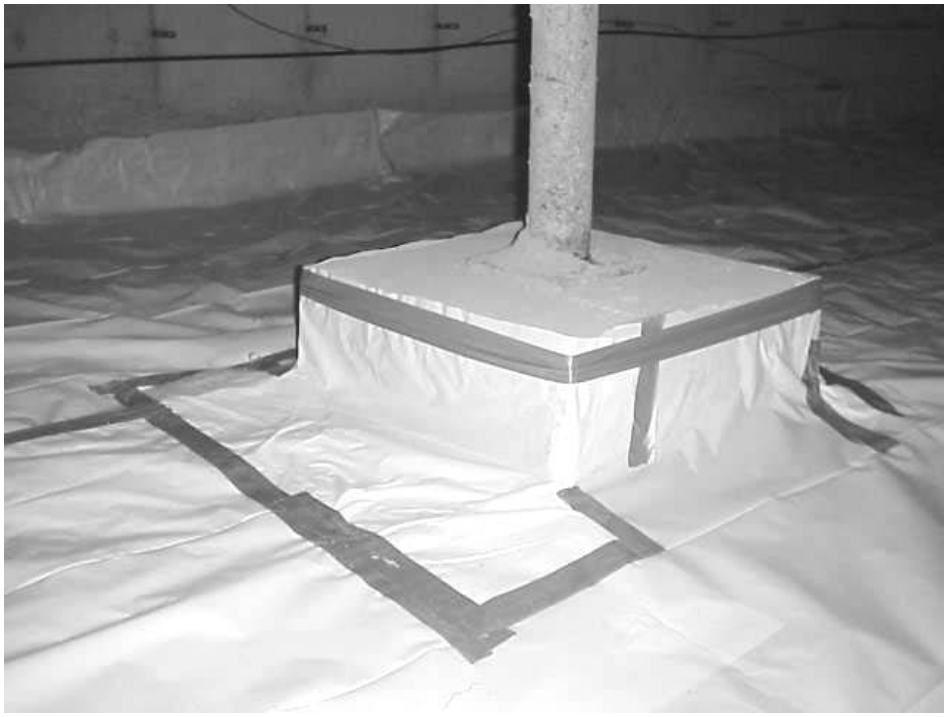
Picture 1

Passive Door Vents in the Closet Doors Were Moved To the Top of The Doors As Recommended

Picture 2

Sealed Vent in Room 5

Picture 3



Debris Removed from Floor of Crawlspace, Plastic Vapor Barrier Installed over Floor

Picture 4

New Gutter Downspout System was Installed Along the Roof Edge

Picture 5

New Gutter Downspout System was Installed along the Roof Edge

Picture 6

Foundation Wall Dry After Gutter/Downspout Installation

Picture 7

Mechanical Exhaust Vent System Installed in the Crawlspace

Picture 8

Crawlspace Exhaust Vent Terminus

Picture 9

Sink Back Splash/Counter Seam Sealed With Caulking

Picture 10

Boiler Room Door Missing Counterweight

Table 1

Indoor Air Test Results - Clarksburg Elementary School, Clarksburg, MA – October 12, 2000

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	418	50	52					
Room 19	927	70	46	17	Yes	Yes	Yes	Exhaust off, door open
Room 18	1140	70	45	17	Yes	Yes	Yes	Exhaust off, door open
Room 16	1545	72	42	29	Yes	Yes	Yes	Exhaust off, door open
Room 17	1250	73	39	20	Yes	Yes	Yes	Exhaust off, window and door open
Gym/Cafeteria	924	72	38	21	Yes	Yes	Yes	
Room 15	1332	72	37	17	Yes	Yes	Yes	Exhaust off, plants on univent
Room 14	1195	72	36	19	Yes	Yes	Yes	Exhaust off
Room 12	809	72	35	22	Yes	Yes	Yes	Door open
Room 13	754	72	35	16	Yes	Yes	Yes	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

Table 2

Indoor Air Test Results - Clarksburg Elementary School, Clarksburg, MA – October 17, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Library	537	73	34	0	Yes	Yes	Yes	
Room 11 – Principal's Office	1062	72	38	1	Yes	No	No	Door open
Room 9	1089	73	38	1	Yes	No	No	Photocopier, door open
Room 8	939	72	35	2	Yes	Yes	Yes	Univent missing part-scheduled to be replaced, exhaust off, door open
Room 7	691	73	34	4	Yes	Yes	No	
Room 6	1655	73	39	24	Yes	Yes (2)	Yes	1 univent blocked by desk, passive exhaust-blocked
Room 4	973	72	38	26	Yes	Yes	Yes	Univent blocked by desk, passive exhaust-fiberglass, door open
Room 3	1370	71	38	15	Yes	Yes	Yes	Univent blocked by box
Room 2	1810	73	38	16	Yes	Yes	Yes	Univent off-blocked by table, passive exhaust-blocked

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Table 3

Carbon Dioxide Air Monitoring Results Comparing October 7, 1999 and October 17, 2000
Clarksburg Elementary School, Clarksburg, MA

Area	Carbon Dioxide *ppm 10/7/99	Occupants in Room 10/7/99	Carbon Dioxide *ppm 10/17/00	Occupants in Room 10/17/00	Change after Repairs (+/-) *ppm	Comments
Outside (Background)	412		418			
Cafeteria	1095	60	924	21	-161	Population 2/3 less on 10/17/00
Library	552	3	537	0	-15	
Room 12	1177	16	809	22	-368	
Room 13	841	20	754	16	-87	
Room 14	1206	13	1195	19	-11	
Room 15	764	12	1332	17	+568	Population increased by 5 occupants
Room 16	1981	24	1545	29	-436	
Room 17	1293	0	1250	20	-43	
Room 18	2000+	12	1140	17	- >860	
Room 19	1050	14	927	17	-123	
Room 2	1240	21	1810	16	+570	Passive exhaust vent
Room 3	1752	23	1370	15	-482	Passive exhaust vent

*** ppm = parts per million parts of air**

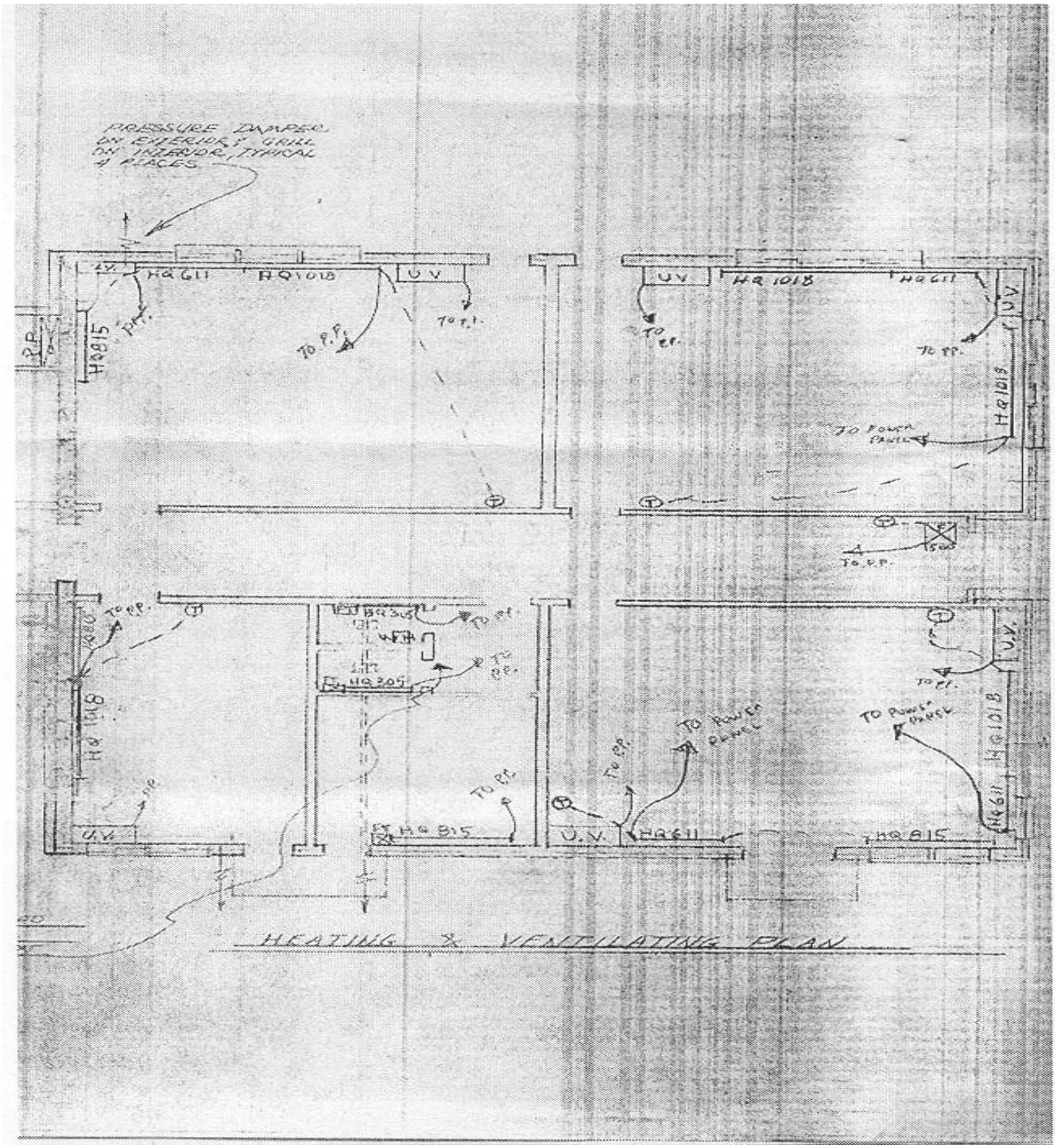
Table 4

Carbon Dioxide Air Monitoring Results Comparing October 7, 1999 and October 17, 2000
Clarksburg Elementary School, Clarksburg, MA

Area	Carbon Dioxide *ppm 10/7/99	Occupants in Room 10/7/99	Carbon Dioxide *ppm 10/17/00	Occupants in Room 10/17/00	Change after Repairs (+/-) *ppm	Comments
Room 4	1303	23	973	26	-331	Passive exhaust vent
Room 5	1411	4	-	0	-	No exhaust vent
Room 6	-	-	1655	24	-	
Room 7	-	-	691	4	-	
Room 8	-	-	939	2	-	
Room 9	981	1	1089	1	+108	

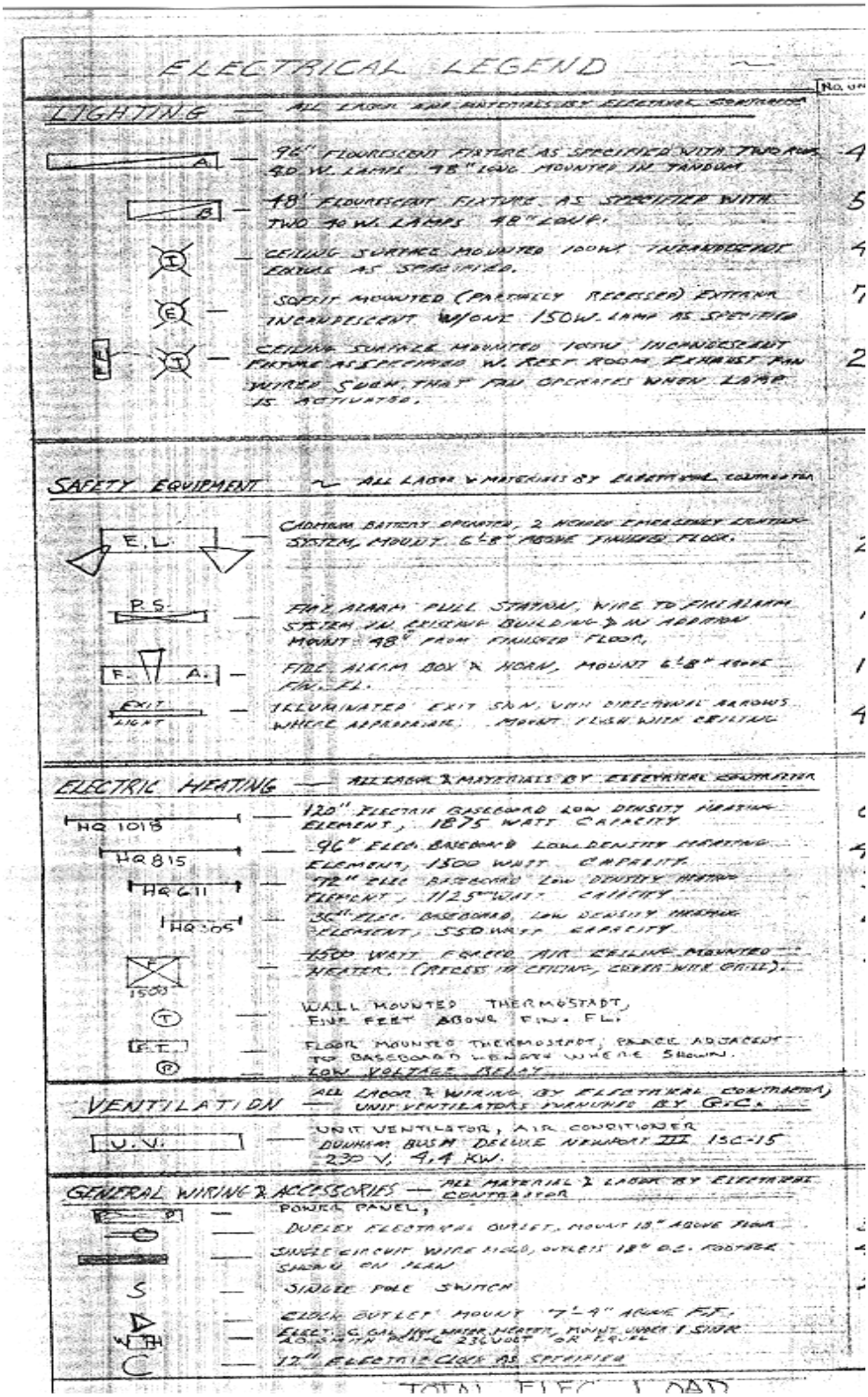
*** ppm = parts per million parts of air**

Heating and Ventilation Blueprint Excerpt



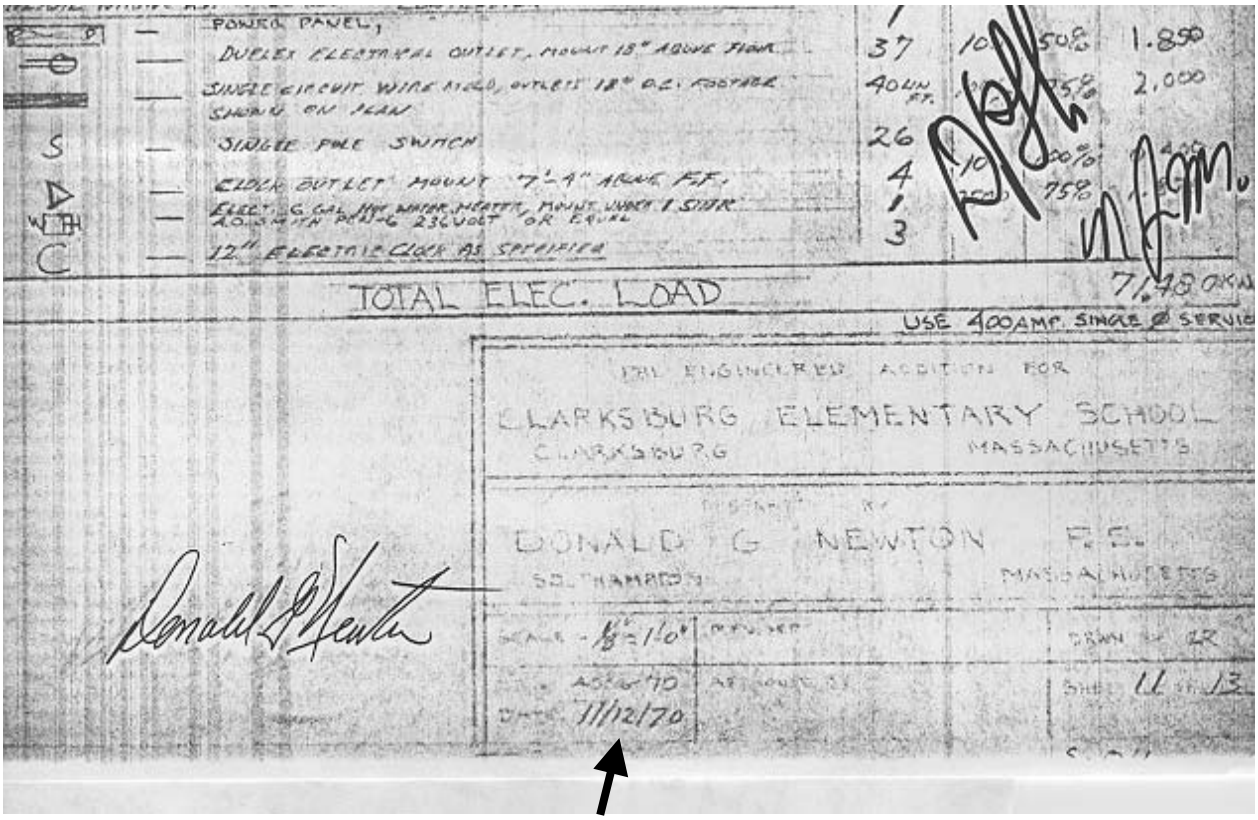
Heating and Ventilation Blueprint,
Please Note That Only Univents Are Included on this Drawing

Heating and Ventilation Blueprint Excerpt



Key for the Heating and Ventilation Blueprint,
Please Note Univents are only Ventilation Equipment Listed

Appendix 1
Page 3
Heating and Ventilation Blueprint Excerpt



Date of Blueprint

The Title Box of the Heating and Ventilation Blueprint,
Please Note that This wing was designed without mechanical ventilation in 1970